WATER RESOURCES REVIEW for APRIL 1972

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

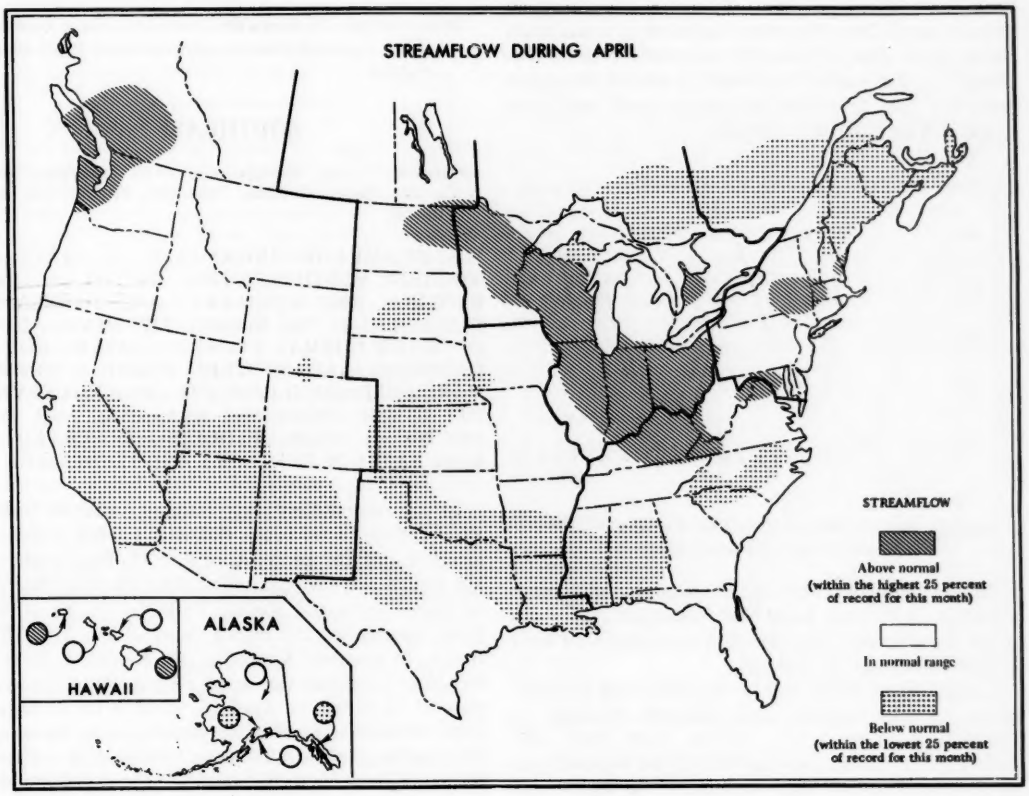
CANADA
DEPARTMENT OF THE ENVIRONMENT
INLAND WATERS BRANCH

STREAMFLOW AND GROUND-WATER CONDITIONS

Streamflows receding into the normal range characterized mountain-fed streams of the West as a result of the below-normal air temperatures of April and the premature snowmelt runoff from low elevations during the relatively high temperatures of the preceding month. However, at the end of April, heavy snowpacks still remained at high elevations in the West.

The largest areas with streamflow in the above-normal range were the southern and western parts of the Western Great Lakes region. Heavy rains caused some flooding in Ohio and Indiana, and in the adjacent Southeast region, in Kentucky and Tennessee. Some streams in the flood areas had monthly discharges that were highest for April for periods of record of up to 50 years.

Contrasting with the high flows noted above, flows far below-median persisted in many areas, including Arizona, southern California, and parts of five States in the southern part of the Midcontinent.



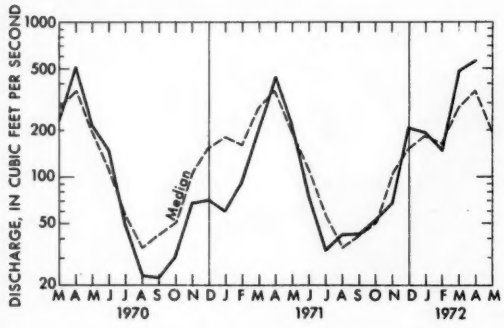
CONTENTS OF THIS ISSUE: Northeast, Southeast, Western Great Lakes region, Midcontinent, West, Alaska; Usable contents of selected reservoirs near end of April 1972; Usable contents of selected reservoirs, March 31, 1972, supplementing list of reservoirs in March issue; Publications on techniques of water-resources investigations; Flow of major rivers during April 1972; Chemical quality of water in the Walnut River basin, south-central Kansas.

NORTHEAST

[Atlantic Provinces and Quebec; Delaware, Maryland, New York, New Jersey, Pennsylvania, and the New England States]

STREAMFLOW INCREASED IN MAINE AND QUEBEC, DECREASED IN CONNECTICUT, AND HAD A MIXED PATTERN OF INCREASING AND DECREASING FLOWS IN OTHER STATES AND PROVINCES IN THE REGION. STREAMFLOW WAS IN THE BELOW-NORMAL RANGE IN MOST OF QUEBEC, THE MARITIME PROVINCES, AND IN MAINE.

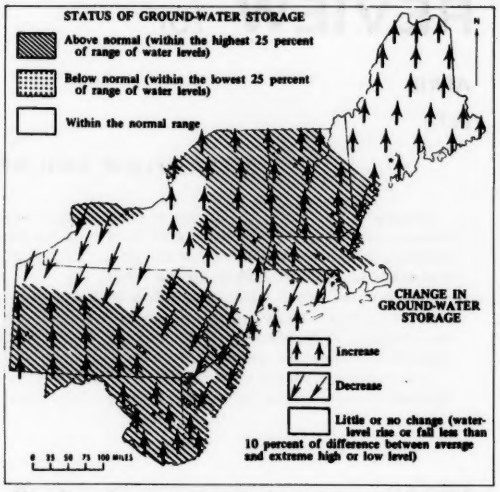
The potential threat of flooding from snowmelt runoff in northern areas was reduced during the month as a result of below-normal temperatures, normal or below-normal precipitation, and in some places an alternating pattern of warm days and cold nights that caused a gradual reduction in the above-normal snowpack in upland areas. Flows in much of central New England receded until about the tenth, increased to a maximum about April 20th, followed by another recession. Discharge for the month as a whole in western Massachusetts was near or within the above-normal range (see graph of Ware River at Coldbrook).



Monthly mean discharge of Ware River at Coldbrook, Mass. (Drainage area, 96.8 square miles.)

On the southern border of the region, monthly mean discharge of Potomac River near Washington, D.C., was in the above-normal range, reaching a maximum on April 17 (daily discharge, 55,200 cfs).

Ground-water levels rose in northern and southern parts of the region, and generally declined in Connecticut, New Jersey, western New York, and eastern Pennsylvania (see map). Monthend levels were in or above the normal range throughout the region, and were especially high in parts of central New England and northeastern New York. Levels were in the above-normal range also in Maryland, Delaware, southern Pennsylvania, and most of New Jersey.


STATUS OF GROUND-WATER STORAGE
Above normal (within the highest 25 percent of range of water levels)
Below normal (within the lowest 25 percent of range of water levels)
Within the normal range
N
CHANGE IN GROUND-WATER STORAGE
Increase
Decrease
Little or no change (water-level rise or fall less than 10 percent of difference between average and extreme high or low level)
0 25 50 75 100 MILES

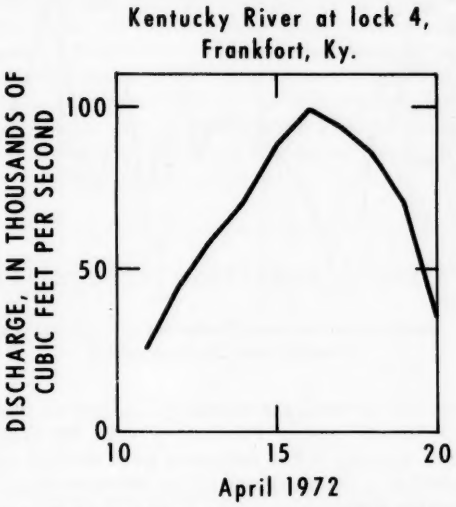
Map above shows ground-water storage near end of April and change in ground-water storage from end of March to end of April.

SOUTHEAST

[Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia]

STREAMFLOW INCREASED IN PARTS OF VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, FLORIDA, AND KENTUCKY, AND DECREASED ELSEWHERE IN THE REGION. THE SMALL AREAS OF BELOW-NORMAL FLOW IN EASTERN NORTH CAROLINA AND WESTERN FLORIDA DURING MARCH EXPANDED INTO THE ADJACENT STATES OF SOUTH CAROLINA, ALABAMA, AND MISSISSIPPI IN APRIL. FLOODING OCCURRED IN SOME PARTS OF KENTUCKY AND TENNESSEE.

In east-central Kentucky, flooding occurred in Salt River and Dix River basins following rainfall of about 8 inches during the period April 9 to 15. Peak stages did not exceed previous maximums although those observed on Beech Fork and Rolling Fork, tributaries of Salt River, approached the record stages of the April 1970 floods. In northern Kentucky, the Kentucky River at lock 4 at Frankfort (see graph on page 3), crested at a stage of 42.25 feet on April 16, which is the 2d highest stage observed since 1894, surpassed only by the 47.46-foot peak stage of the 1937 flood. A floodwall in Frankfort, completed by the Corps of Engineers in September 1970, reportedly prevented damage estimated at about 6 million dollars. In northeastern Kentucky, flooding occurred along Stoner Creek and South Fork Licking River, as a result of rains on April 22, 23, causing some



Daily discharges of Kentucky River at lock 4, at Frankfort, Ky., showing the high daily discharge that occurred on April 16.

damage, but peak stages were lower than the previous peaks of record. Monthly mean discharges at index stations, Licking River at Catawba, in the north, and Green River at Munfordville, in the south, increased and were in the above-normal range during April.

In eastern Tennessee, severe thunderstorms on April 12, caused local flooding on small streams. In the community of Hartford, in Cocke County, one death and considerable property damage occurred. In western Tennessee, thunderstorms caused some local flooding on small streams April 22–24.

In Alabama, flows declined sharply at index stations, Cahaba River at Centreville, and Conecuh River at Brantley, and were in the below-normal range for the first time in 17 and 22 months, respectively, at those stations.

Streamflow continued to decrease in northern Florida but increased in the south. Below-normal flow continued in the northwest, and normal flow persisted elsewhere in the State. In the north-central part of the State, flow of Silver Springs continued at 740 cfs, 94 percent of normal. In the southeastern part, flow southward through the Tamiami Canal outlets, 40-mile bend to Monroe, increased 16 cfs, to 40 cfs, more than 14 times the normal flow for April. Flow of Miami Canal at Miami increased by 59 cfs, to 142 cfs, 311 percent of normal.

Ground-water levels generally rose in Kentucky, West Virginia, western and central North Carolina, and northern and central Florida. Levels declined slightly in southeastern Florida and in the Piedmont of Georgia; and declined also in southeastern Georgia in outlying areas of Brunswick and Savannah, in the Coastal Plain of North Carolina, and in Alabama. Monthend levels were above average in Kentucky, North Carolina, and most of West Virginia; and were below average in most of Florida.

WESTERN GREAT LAKES REGION

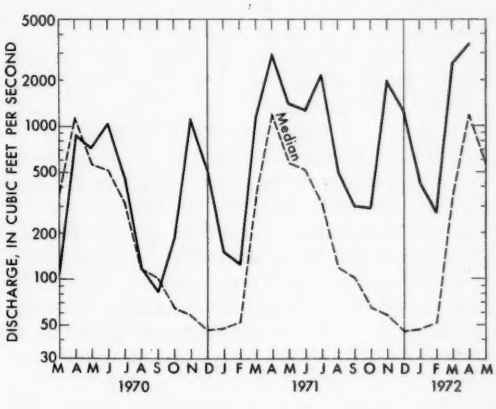
[Ontario; Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin]

STREAMFLOW INCREASED AND WAS IN THE ABOVE-NORMAL RANGE IN MOST OF THE REGION, BUT FLOWS WERE IN THE BELOW-NORMAL RANGE IN A LARGE PART OF ONTARIO. HEAVY RAINS CAUSED SOME FLOODING IN OHIO AND INDIANA.

In south-central Ohio, monthly mean discharge of Scioto River at Chillicothe (drainage area, 3,849 square miles), was 16,400 cfs, highest for April in the 51 years of record. As a result of heavy showers and thunderstorms moving across the State each of the first three weeks of the month, major streams experienced peaks with recurrence intervals of from 2 to 7 years. Minor flooding occurred in the Sandusky and upper Scioto River basins between the 20th and 22d. On the 12th, Mad River at Zanesfield (drainage area, 7.31 square miles) in the western part of the State, peaked at about 2,200 cfs, as a result of nearly 3 inches of rain in 90 minutes; this peak discharge was the highest in the 26 years of record, surpassing the previous high of 1,380 cfs in 1948.

In Indiana, minor flooding occurred on all streams; major flooding was confined to the lowland areas of the Wabash and White Rivers. Some residents were evacuated from Decatur, in the Maumee River basin. The south-central part of the State had received nearly 10 inches of rain between the 5th and 20th.

In northern Wisconsin and Minnesota, snowmelt runoff caused high flows on many streams, but little or no flooding was reported. In east-central Minnesota, monthly mean discharge of Crow River at Rockford was in the above-normal range for the 19th consecutive month (see graph).



Monthly mean discharge of Crow River at Rockford, Minn. (Drainage area, 2,520 square miles.)

Ground-water levels in water-table wells generally rose; but declined in southern Minnesota. Monthend

levels were above average in Minnesota, Ohio, and southern Indiana; were near average in northern Indiana; and were below average in the central part of Michigan's Upper Peninsula and the southeastern part of the Lower Peninsula. In deep artesian aquifers, levels continued to decline in the Milwaukee, Wis., area, but rose in the Minneapolis-St. Paul, Minn., area.

MIDCONTINENT

[Manitoba and Saskatchewan; Arkansas, Iowa, Kansas, Louisiana, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas]

STREAMFLOW INCREASED IN MANITOBA, EASTERN NORTH DAKOTA, MISSOURI, OKLAHOMA, AND NORTHERN ARKANSAS, AND DECREASED ELSEWHERE IN THE REGION. ABOVE-NORMAL FLOW CONTINUED IN EASTERN NORTH DAKOTA, AND BELOW-NORMAL FLOWS PERSISTED IN WESTERN KANSAS, SOUTHERN OKLAHOMA, SOUTHERN ARKANSAS AND ADJACENT AREAS OF LOUISIANA, AND IN EAST- AND WEST-CENTRAL TEXAS.

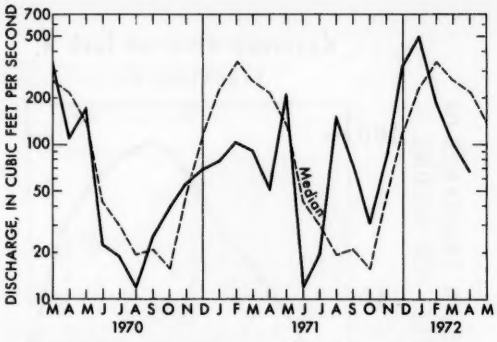
In North Dakota, monthly mean discharge of Red River of the North at Grand Forks, on the eastern boundary, was more than double that for March as a result of heavy precipitation during the period April 2–15, combined with the slow recession from snowmelt peaks.

In Missouri, streamflow increased markedly as a result of locally intense thunderstorms over many sections of the State. Minor flooding occurred on some streams at times between April 15 and 25, causing a small amount of damage.

In contrast, monthly mean discharge of Bad River near Fort Pierre (drainage area, 3,107 square miles), in central South Dakota, decreased from 150 percent of median in March to about 3 percent of median in April; monthly mean discharge was less than 4 cfs. This stream was dry during January 1972. In northwestern Kansas, monthly mean discharge of Saline River near Russell (drainage area, 1,502 square miles), decreased to 13.4 cfs, one third of median. Streamflow remained far below normal also in southwestern Oklahoma, only 23 percent of median on Washita River near Durwood.

In northern Louisiana, monthly mean discharge of Saline Bayou near Lucky declined to 31 percent of the April median (see graph) and continued in the below-normal range for the 3d consecutive month. In southern Louisiana, flows of Calcasieu River near Oberlin and Amite River near Denham Springs also decreased sharply and were below the normal range for April. In southern Arkansas, monthly mean discharge (604 cfs) of Saline River near Rye (drainage area, 2,062 square miles), was lowest for the month in the 35 years of record.

In Manitoba, monthly mean discharge of Waterhen River below Waterhen Lake increased almost twofold



Monthly mean discharge of Saline Bayou near Lucky, La. (Drainage area, 154 square miles.)

from that of March and was nearly 1.8 times the median flow for the month. The level of Lake Winnipeg at Gimli, averaged 715.68 feet above mean sea level, a rise of 0.42 foot, and was about 2.8 feet above the long-term mean for April.

Ground-water levels rose in North Dakota and Iowa; remained about the same in most of Kansas and Nebraska (except in heavily pumped areas); and declined in much of the southern part of the region. In Arkansas, there was little or no change in levels in the shallow aquifer in the east-central rice-irrigation area, nor in the industrial-use aquifer (Sparta Sand) at Pine Bluff; levels fell and were below average at El Dorado. Levels declined also in the Chicot aquifer in southwestern Louisiana, becoming lowest of record for April. In Texas, levels fell at Austin, San Antonio, Houston, and El Paso.

WEST

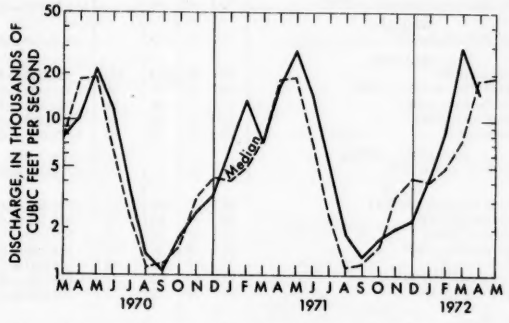
[Alberta and British Columbia; Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming]

STREAMFLOW GENERALLY DECREASED IN THE REGION BUT INCREASED IN SOME PARTS OF THE NORTHERN HALF. BELOW-NORMAL TEMPERATURES AND THE ABSENCE OF LOW-ALTITUDE SNOW COVER CONTRIBUTED TO THE DECLINE IN MOUNTAIN AREAS AND BROUGHT FLOWS INTO THE NORMAL RANGE IN MOST OF THE NORTHERN STATES AND PROVINCES. THE AREA OF BELOW-NORMAL FLOW THAT HAD BEEN LIMITED MAINLY TO ARIZONA AND SOUTHERN CALIFORNIA, EXPANDED ACROSS THE ENTIRE SOUTHERN PART OF THE REGION DURING APRIL.

Mountain-fed streams of the West generally decreased into the normal range as a result of below-normal temperatures and the fact that the above-normal temperatures of March had depleted

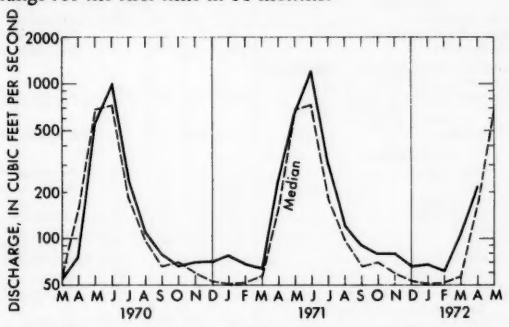
the snowpack at low elevations. However, heavier-than-normal snowpacks remained at high elevations in Idaho, Montana, and some other parts of the region.

Flows in the above-normal range were generally limited to British Columbia and western Washington. In contrast, flows at most index stations in Washington, Oregon, and the northern parts of California and Nevada were roughly half of March flows. Flow of Spokane River at Spokane, in eastern Washington (see graph), is typical of many of those stations.



Monthly mean discharge of Spokane River at Spokane, Wash.
(Drainage area, 4,290 square miles.)

In north-central Idaho, flow of Salmon River at White Bird was below the monthly mean for the first time since May 1970, and in eastern Idaho, flow of Snake River near Heise increased seasonally but was in the normal range for the first time since June 1971. Nearby, in northern Utah, flow of Weber River near Oakley, also increased seasonally (see graph) but was in the normal range for the first time in 11 months.



Monthly mean discharge of Weber River near Oakley, Utah
(Drainage area, 163 square miles.)

In the southern part of the region, flows of some streams in Arizona and New Mexico were below normal. For example, in southeastern Arizona, monthly mean discharge of Salt River near Roosevelt (drainage area, 4,310 square miles) was only 20 percent of median, and at monthend the daily discharge was less than 200 cfs, about equal to the lowest daily April flow (in 1959) in the 59 years of record. There was again no flow in Little Colorado River near Cameron in the northern part of the State.

Contents of the Colorado River Storage Project decreased 144,800 acre-feet during the month. In Utah, elevation of Great Salt Lake rose 0.45 foot during April, to 4,199.55 feet above mean sea level, 2.00 feet higher than a year ago.

Ground-water levels generally declined. Monthend levels were above average in Montana, Washington, southern Idaho, and northern Nevada; remained near average in southern California; and continued below average in southern Arizona and New Mexico.

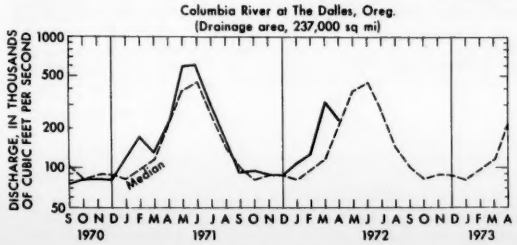
ALASKA

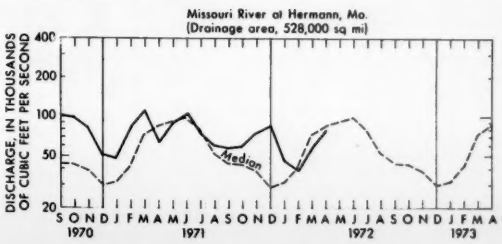
Streamflow increased slightly in the south and southeast, and decreased in south-central and interior areas; but the normal seasonal increase in flow throughout the State was delayed by below-normal temperatures. Flow of the Little Susitna River near Palmer, in the south-central area, was in the below-normal range for the first time in 7 months. In the southeast, flow of Sheep Creek near Juneau also was in the below-normal range as the result of a 1 percent increase in flow instead of the 60 percent increase that is normal for the month. On Kodiak Island, near the shoreward end of the Alaskan Peninsula, April flow of Uganik River near Kodiak was the lowest observed in 20 years. Municipal water (from reservoir storage) for the city of Kodiak was in short supply and was being rationed to users.

Greater-than-normal snow accumulation, and delayed snowmelt, have created a threat of possible flooding in Chena River basin near Fairbanks, in central Alaska, in the event of a sudden warming trend.

Ground-water levels declined in the Anchorage area, especially in deep artesian wells near the center of municipal pumping. However, levels rose near monthend in the vicinity of the North Fork Campbell Creek fan, southeast of Anchorage, where local recharge apparently occurred.

HYDROGRAPHS OF TWO MAJOR RIVERS


Columbia River at The Dalles, Oreg.
(Drainage area, 237,000 sq mi)
DISCHARGE, IN THOUSANDS OF CUBIC FEET PER SECOND
1000
500
200
100
50
Median
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1970
1971
1972
1973


Missouri River at Hermann, Mo.
(Drainage area, 528,000 sq mi)
DISCHARGE, IN THOUSANDS OF CUBIC FEET PER SECOND
400
200
100
50
20
Median
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1970
1971
1972
1973

Provisional data; subject to revision

USABLE CONTENTS OF SELECTED RESERVOIRS NEAR END OF APRIL 1972

[Contents are expressed in percent of reservoir capacity. The usable storage capacity of each reservoir is shown in the column headed "Normal maximum."]

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Mar. 1972	End of Apr. 1972	End of Apr. 1971	Average for end of Apr.	Normal maximum
	Percent of normal maximum				
NORTHEAST REGION					
NOVA SCOTIA					
Rossignol, Mulgrave, Falls Lake, St. Margaret's Bay, Black, and Ponhook Reservoirs (P)	59	72	93	76	223,400 (a)
QUEBEC					
Gouin (P)	30	29	56	53	6,487,000 ac-ft
Allard (P)	32	56	69	78	280,600 ac-ft
MAINE					
Seven reservoir systems (MP)	18	28	48	64	179,300 mcf
NEW HAMPSHIRE					
Lake Winnipesaukee (PR)	68	88	97	97	7,200 mcf
Lake Francis (FPR)	12	22	32	53	4,326 mcf
First Connecticut Lake (P)	7	6	17	48	3,330 mcf
VERMONT					
Somerset (P)	57	64	51	73	2,500 mcf
Harriman (P)	9	51	43	77	5,060 mcf
MASSACHUSETTS					
Cobble Mountain and Borden Brook (MP)	81	95	93	88	3,394 mcf
NEW YORK					
Great Sacandaga Lake (FPR)	39	87	79	90	34,270 mcf
Indian Lake (FMP)	41	59	66	91	4,500 mcf
New York City reservoir system (MW)	98	102	89	.....	547,500 mg
NEW JERSEY					
Wanaque (M)	100	100	99	93	27,730 mg
PENNSYLVANIA					
Wallenpaupack (P)	81	88	86	79	6,875 mcf
Pymatuning (FMR)	100	105	99	98	8,191 mcf
MARYLAND					
Baltimore municipal system (M)	101	101	100	92	85,340 mg
SOUTHEAST REGION					
NORTH CAROLINA					
Bridgewater (Lake James) (P)	79	85	85	93	12,580 mcf
High Rock Lake (P)	68	76	78	85	10,230 mcf
Narrows (Badin Lake) (P)	99	100	105	103	5,616 mcf
SOUTH CAROLINA					
Lake Murray (P)	85	89	96	80	70,300 mcf
Lakes Marion and Moultrie (P)	86	82	78	79	81,100 mcf
SOUTH CAROLINA--GEORGIA					
Clark Hill (FP)	73	74	79	75	75,360 mcf
GEORGIA					
Burton (PR)	91	91	92	91	104,000 ac-ft
Lake Sidney Lanier (FMPR)	60	62	63	63	1,686,000 ac-ft
Sinclair (MPR)	88	94	92	92	214,000 ac-ft
ALABAMA					
Lake Martin (P)	90	94	99	95	1,373,000 ac-ft
TENNESSEE VALLEY					
Clinch Projects: Norris and Melton Hill Lakes (FPR)	59	79	66	56	1,166,000 cfsd
Holston Projects: South Holston, Watauga, Boone, Fort Patrick Henry, and Cherokee Lakes (FPR)	63	81	64	63	1,452,000 cfsd
Douglas Lake (FPR)	43	76	60	59	715,800 cfsd
Hiwassee Projects: Chatuge, Nottely, Hiwassee, Apalachia, Blue Ridge, Ocoee 3, and Parksville Lakes (FPR)	69	81	81	75	523,700 cfsd
Little Tennessee Projects: Nantahala, Thorpe, Fontana, and Chilhowee Lakes (FPR)	70	85	80	74	751,400 cfsd
WESTERN GREAT LAKES REGION					
WISCONSIN					
Chippewa and Flambeau (PR)	30	63	89	69	15,900 mcf
Wisconsin River (21 reservoirs) (PR)	12	71	80	69	17,400 mcf
MINNESOTA					
Mississippi River headwater system (FMR)	21	37	29	30	1,640,000 ac-ft

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Mar. 1972	End of Apr. 1972	End of Apr. 1971	Average for end of Apr.	Normal maximum
	Percent of normal maximum				
MIDCONTINENT REGION					
NORTH DAKOTA					
Lake Sakakawea (Garrison) (FIPR)	98	95	91	.....	22,640,000 ac-ft
NEBRASKA					
Lake McConaughy (IP)	91	94	95	77	1,948,000 ac-ft
OKLAHOMA					
Keystone (FPR)	83	80	128	102	661,000 ac-ft
Lake O' The Cherokees (FPR)	80	90	90	90	1,492,000 ac-ft
Tenkiller Ferry (FPR)	85	97	86	90	628,200 ac-ft
Lake Altus (FIMR)	21	21	20	55	134,500 ac-ft
Eufaula (FPR)	80	83	79	81	2,378,000 ac-ft
OKLAHOMA--TEXAS					
Lake Texoma (FMPRW)	81	80	82	90	2,722,000 ac-ft
TEXAS					
Possum Kingdom (IMPRW)	94	93	60	77	724,500 ac-ft
Buchanan (IMPW)	96	95	82	79	955,200 ac-ft
Bridgeport (IMW)	61	61	74	68	270,900 ac-ft
Eagle Mountain (IMW)	94	88	90	88	182,700 ac-ft
Medina Lake (I)	97	93	53	48	254,000 ac-ft
Lake Travis (FIMPRW)	93	87	83	77	1,144,000 ac-ft
Lake Kemp (IMW)	27	24	26	53	461,800 ac-ft
THE WEST					
ALBERTA					
Spray (P)	34	29	6	13	210,000 ac-ft
Lake Minnewanka (P)	49	47	30	25	199,700 ac-ft
St. Mary (I)	81	76	69	70	320,800 ac-ft
WASHINGTON					
Franklin D. Roosevelt Lake (IP)	26	36	9	54	5,232,000 ac-ft
Lake Chelan (PR)	29	29	27	41	676,100 ac-ft
IDAHO--WYOMING					
Upper Snake River (7 reservoirs) (IMP)	77	67	66	80	4,282,000 ac-ft
WYOMING					
Pathfinder, Seminoe, Alcova, Kortes, and Glendo Reservoirs (I)	71	73	66	38	3,016,000 ac-ft
Buffalo Bill (IP)	75	39	39	62	421,300 ac-ft
Boysen (FIP)	71	63	46	58	802,000 ac-ft
Keyhole (F)	93	90	79	34	199,900 ac-ft
COLORADO					
John Martin (FIR)	7	0	0	17	364,400 ac-ft
Colorado–Big Thompson project (I)	75	77	81	53	722,600 ac-ft
Taylor Park (IR)	66	71	78	58	106,000 ac-ft
COLORADO RIVER STORAGE PROJECT					
Lake Powell; Flaming Gorge, Navajo, and Blue Mesa Reservoirs (IFPR)	55	55	49	.....	31,276,500 ac-ft
UTAH--IDAHO					
Bear Lake (IPR)	79	85	85	61	1,421,000 ac-ft
CALIFORNIA					
Hetch Hetchy (MP)	23	23	33	38	360,400 ac-ft
Lake Almanor (P)	68	75	82	53	1,036,000 ac-ft
Shasta Lake (FIPR)	92	100	103	91	4,377,000 ac-ft
Millerton Lake (FI)	59	66	81	67	503,200 ac-ft
Pine Flat (FI)	43	47	71	59	1,014,000 ac-ft
Isabella (FIR)	21	20	33	28	551,800 ac-ft
Folsom (FIP)	71	85	82	72	1,000,000 ac-ft
Lake Berryessa (FIMW)	87	86	100	88	1,600,000 ac-ft
Clair Engle Lake (Lewiston) (P)	95	96	97	90	2,438,000 ac-ft
CALIFORNIA--NEVADA					
Lake Tahoe (IPR)	74	78	80	60	744,600 ac-ft
NEVADA					
Rye Patch (I)	105	105	106	54	179,100 ac-ft
ARIZONA--NEVADA					
Lake Mead and Lake Mohave (FIMP)	67	67	64	62	27,970,000 ac-ft
ARIZONA					
San Carlos (IP)	11	9	0	19	948,600 ac-ft
Salt and Verde River system (IMPR)	48	45	47	48	2,073,000 ac-ft
NEW MEXICO					
Conchas (FIR)	44	40	62	.....	352,600 ac-ft
Elephant Butte and Caballo (FIPR)	9	8	14	.....	2,539,000 ac-ft

[a] Thousands of kilowatt-hours.

USABLE CONTENTS OF SELECTED RESERVOIRS, MARCH 31, 1972, SUPPLEMENTING LIST OF RESERVOIRS IN MARCH ISSUE OF THE WATER RESOURCES REVIEW

[Contents are expressed in percent of reservoir capacity. The usable storage capacity of each reservoir is shown in the column headed "Normal maximum."]

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Feb. 1972	End of Mar. 1972	End of Mar. 1971	Average for end of Mar.	Normal maximum ac-ft
	Percent of normal maximum				
SOUTHEAST REGION					
KENTUCKY					
Herrington Lake (P)	98	78	41	64	123,000
Lake Cumberland (FP)	109	98	93	97	3,988,000
WESTERN GREAT LAKES REGION					
OHIO					
Milton and Berlin (FRW)	------	69	61	57	120,300
Hoover (MR)	------	75	74	70	85,890
MIDCONTINENT REGION					
ARKANSAS					
Norfork (FPR)	84	83	88	90	1,249,000
MISSOURI					
Lake of the Ozarks (PR)	82	77	69	72	1,218,000
SOUTH DAKOTA					
Big Bend (FPR)	101	101	102	87	1,725,000
Fort Randall (FIPR)	76	85	74	76	5,108,000
Oahe (FIPR)	80	88	94	------	22,530,000
Lewis and Clark Lake (FIPR)	80	83	82	87	477,000
Angostura (FIPR)	82	98	80	80	127,600
Belle Fourche (IR)	83	89	84	60	185,200
Pactola (FIMR)	96	94	94	70	55,700
Shadehill (FI)	63	105	118	82	81,400
TEXAS					
Livingston (MWIR)	100	100	82	------	1,750,000
Toledo Bend (MWIRP)	91	96	93	94	4,473,000
International Falcon (IPRF)	100	100	48	------	2,764,000
Twin Buttes (MIF)	52	49	0	0	177,800
Red Bluff (IRP)	14	14	20	32	307,000
THE WEST					
BRITISH COLUMBIA					
Kootenay Lake (P)	58	36	18	19	787,000
WASHINGTON					
Lake Cushman (P)	60	88	71	82	371,900
Ross (FMP)	27	43	36	------	1,052,000
Lake Merwin(P)	95	89	80	90	263,400
OREGON					
McKay (I)	84	87	60	68	73,830
Lake Owyhee (I)	87	97	98	71	715,000
Upper Klamath Lake (IP)	81	83	90	77	584,000
IDAHO					
Arrowrock, Anderson Ranch, and Lucky Peak Reservoirs and Lake Lowell (FIPR)	55	61	52	63	1,235,000
Pend Oreille Lake (FPR)	37	64	52	53	1,561,000
Coeur d' Alene Lake (P)	90	236	68	98	177,900
MONTANA					
Fort Peck (FIPR)	85	87	87	58	19,140,000
Canyon Ferry(FIMPR)	78	79	71	76	2,043,000
Fresno (IR)	29	94	75	65	127,200
Tiber (FIR)	37	38	35	46	1,313,000
Bighorn Lake (I)	68	68	64	56	1,356,000
Six major hydroelectric reservoirs (P)	67	67	80	55	583,000
Flathead Lake (FIPR)	51	58	41	42	1,791,000
Hungry Horse (FIP)	50	44	58	61	3,428,000
Noxon Rapids (PR)	88	52	61	60	334,600
CALIFORNIA					
El Capitan (IM)	13	15	25	------	112,800
San Vicente (M)	79	78	75	------	90,230
ARIZONA					
Bartlett (FIMR)	55	33	91	------	178,500
Horseshoe (FIMPR)	1	1	8	------	139,200

PUBLICATIONS ON TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

Twenty-five manuals by the U.S. Geological Survey have been published to date in the series on techniques describing procedures for planning and executing specialized work in water-resources investigations. The material is grouped under major subject headings called books and is further divided into sections and chapters. For example, Section A of Book 3 (Applications of hydraulics) is on surface water. The chapter, the unit of publication, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises. The reports listed below are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

NOTE: When ordering any of these publications from the Superintendent of Documents, please give the title, book number, chapter number, and "U.S. Geological Survey Techniques of Water-Resources Investigations."

2–E1. *Application of borehole geophysics to water-resources investigations,* by W.S. Keys and L.M. MacCary: USGS—TWRI Book 2, Chapter E1. 1971. 126 pages. $1.75.

3–A1. *General field and office procedures for indirect discharge measurements,* by M.A. Benson and Tate Dalrymple: USGS—TWRI Book 3, Chapter A1. 1967. 30 pages. $0.25.

3–A2. *Measurement of peak discharge by the slope-area method,* by Tate Dalrymple and M.A. Benson: USGS—TWRI Book 3, Chapter A2. 1967. 12 pages. $0.20.

3–A3. *Measurement of peak discharge at culverts by indirect methods,* by G.L. Bodhaine: USGS—TWRI Book 3, Chapter A3. 1968. 60 pages. $0.40.

3–A4. *Measurement of peak discharge at width contractions by indirect methods,* by H.F. Matthai: USGS—TWRI Book 3, Chapter A4. 1967. 44 pages. $0.35.

3–A5. *Measurement of peak discharge at dams by indirect methods,* by Harry Hulsing: USGS—TWRI Book 3, Chapter A5. 1967. 29 pages. $0.30.

3–A6. *General procedure for gaging streams,* by R.W. Carter and Jacob Davidian: USGS—TWRI Book 3, Chapter A6. 1968. 13 pages. $0.20.

3–A7. *Stage measurements at gaging stations,* by T.J. Buchanan and W.P. Somers: USGS—TWRI Book 3, Chapter A7. 1968. 28 pages. $0.45.

3–A8. *Discharge measurements at gaging stations,* by T.J. Buchanan and W.P. Somers: USGS—TWRI Book 3, Chapter A8. 1969. 65 pages. $0.70.

3–A11. *Measurement of discharge by moving-boat method,* by G.F. Smoot and C.E. Novak: USGS—TWRI Book 3, Chapter A11. 1969. 22 pages. $0.40.

3–A12. *Fluorometric procedures for dye tracing,* by J.F. Wilson, Jr.: USGS—TWRI Book 3, Chapter A12. 1968. 31 pages. $0.35.

3–B1. *Aquifer-test design, observation, and data analysis,* by R.W. Stallman: USGS—TWRI Book 3, Chapter B1. 1971. 26 pages. $0.40.

3–C1. *Fluvial sediment concepts,* by H.P. Guy: USGS—TWRI Book 3, Chapter C1. 1970. 55 pages. $0.65.

3–C2. *Field methods for fluvial sediment measurements,* by H.P. Guy and V.W. Norman: USGS—TWRI Book 3, Chapter C2. 1970. 59 pages. $0.70.

3–C3. *Computation of fluvial-sediment discharge,* by George Porterfield: USGS—TWRI Book 3, Chapter C3. 1972. 66 pages. $0.75.

4–A1. *Some statistical tools in hydrology,* by H.C. Riggs: USGS—TWRI Book 4, Chapter A1. 1968. 39 pages. $0.30.

4–A2. *Frequency curves,* by H.C. Riggs: USGS—TWRI Book 4, Chapter A2. 1968. 15 pages. $0.20.

4–D1. *Computation of rate and volume of stream depletion by wells,* by C.T. Jenkins: USGS—TWRI Book 4, Chapter D1. 1970. 17 pages. $0.30.

5–A1. *Methods for collection and analysis of water samples for dissolved minerals and gases,* by Eugene Brown, M. W. Skougstad, and M.J. Fishman: USGS—TWRI Book 5, Chapter A1. 1970. 160 pages. $2.00.

5–A2. *Determination of minor elements in water by emission spectroscopy,* by P.R. Barnett and E.C. Mallory, Jr.: USGS—TWRI Book 5, Chapter A2. 1971. 31 pages. $0.50.

5–A3. *Methods for analysis of organic substances in water,* by D.F. Goerlitz and Eugene Brown: USGS—TWRI Book 5, Chapter A3. 1972. 40 pages. $0.50.

5–C1. *Laboratory theory and methods for sediment analysis,* by H.P. Guy: USGS—TWRI Book 5, Chapter C1. 1969. 58 pages. $0.65.

7–C1. *A digital model for aquifer evaluation,* by G.F. Pinder: USGS—TWRI Book 7, Chapter C1. 1970. 18 pages. $0.35.

8–A1. *Methods of measuring water levels in deep wells,* by M.S. Garber and F.C. Koopman: USGS—TWRI Book 8, Chapter A1. 1968. 23 pages. $0.25.

8–B2. *Calibration and maintenance of vertical-axis type current meters,* by G.F. Smoot and C.E. Novak: USGS—TWRI Book 8, Chapter B2. 1968. 15 pages. $0.40.

Provisional data; subject to revision

FLOW OF MAJOR RIVERS DURING APRIL 1972

River and location	Drainage area (square miles)	Mean annual discharge through September 1970 (cfs)	April 1972					
			Monthly mean discharge (cfs)	Percent of median monthly discharge[1]	Change in discharge from previous month (percent)	Discharge near end of month		
						(cfs)	(mgd)	Date
St. Lawrence River at Lake St. Lawrence[2]	295,200	239,100	272,500	112	+ 7	284,000	184,000	30
Delaware River at Trenton, N.J	6,780	11,360	23,130	94	- 9	26,000	16,800	27
Susquehanna River at Harrisburg, Pa	24,100	33,670	84,480	115	- 22	46,100	29,800	30
Potomac River near Washington, D.C	11,560	10,650	25,000	144	- 10	23,000	14,900	30
Altamaha River at Doctortown, Ga	13,600	13,380	15,250	74	- 29	9,830	6,350	23
Tombigbee River near Coatopa, Ala[3]	15,400	22,160	15,960	46	- 53	10,000	6,500	30
Missouri River at Hermann, Mo	528,200	77,480	78,650	95	+ 31	90,200	58,300	28
Ohio River at Louisville, Ky[4]	91,170	110,600	358,500	172	+ 24	510,000	330,000	26
Mississippi River near Vicksburg, Miss[5]	1,144,500	552,700	741,600	76	- 8	1,004,000	649,000	30
Colorado River near Grand Canyon, Ariz	137,800	.....	13,270	.....	+135	.....	.....	.....
Columbia River at The Dalles, Oreg[6]	237,000	194,000	235,000	114	- 27	.....	.....	.....
Fraser River at Hope, British Columbia	78,300	95,300	74,000	149	+ 39	73,300	47,400	27

[1]Reference period 1931–60 or 1941–70.

[2]Records furnished by Department of the Army, Corps of Engineers, Buffalo District. Discharges shown are considered to be the same as those at Ogdensburg, N.Y., which is directly opposite Prescott, Ontario.

[3]At Demopolis lock and dam.

[4]Records furnished by U.S. Army, Corps of Engineers.

[5]Records of daily discharge computed jointly by Corps of Engineers and Geological Survey.

[6]Discharge (adjusted for upstream storage) determined from information furnished by Bureau of Reclamation, Corps of Engineers, and Geological Survey.

WATER RESOURCES REVIEW — APRIL 1972

Cover map shows generalized pattern of streamflow for April based on 22 index stream-gaging stations in Canada and 130 index stations in the United States. Alaska and Hawaii inset maps show streamflow only at the index gaging stations which are located near the points shown by the arrows.

Streamflow for April 1972 is compared with flow for April in the 30-year reference period 1931–60 or 1941–70. Streamflow is considered to be *below normal* if it is within the range of the low flows that have occurred 25 percent of the time (below the lower quartile) during the reference period. Flow for April is considered to be *above normal* if it is within the range of the high flows that have occurred 25 percent of the time (above the upper quartile).

Flow higher than the lower quartile but lower than the upper quartile is described as being within the *normal range*. In the Water Resources Review *normal flow* is defined as the median of the 30 flows of April during the reference period. The normal (median) has been obtained by ranking those 30 flows in their order of magnitude; the highest flow is number 1, the lowest flow is number 30, and the average of the 15th and 16th highest flows is the normal (median).

The normal is an average (but not an arithmetic average) or middle value; half of the time you would expect the April flows to be below the median and half of the time to be above the median. Shorter reference periods are used for the Alaska index stations because of the limited records available.

Statements about *ground-water levels* refer to conditions near the end of April. Water level in each key observation well is compared with average level for the end of April determined from the entire past record for that well or from a 20-year reference period, 1951–70. *Changes in ground-water levels*, unless described otherwise, are from the end of March to the end of April.

The Water Resources Review is published monthly. Special-purpose and summary issues are also published. In the United States, issues of the Review are free on application to the Water Resources Review, U.S. Geological Survey, Washington, D.C. 20242.

This issue was prepared by J.C. Kammerer, H.D. Brice, E.W. Coffay, and L.C. Fleshmon from reports of the field offices, May 4, 1972.

CHEMICAL QUALITY OF WATER IN THE WALNUT RIVER BASIN, SOUTH-CENTRAL KANSAS

The accompanying abstract (abridged), map, and graph are from the report, *Chemical quality of water in the Walnut River basin, south-central Kansas,* by R.B. Leonard: U.S. Geological Survey Water-Supply Paper 1982, 113 pages, 1972; prepared in cooperation with the Kansas State Department of Health, Environmental Health Services, Topeka, Kansas. Water-Supply Paper 1982 may be purchased for $3.75 from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

ABSTRACT

Improper disposal of oil-field brine and other wastes has adversely affected the naturally diverse chemical quality of much of the water in the Walnut River basin, south-central Kansas.

The basin is an area of about 2,000 square miles in the shape of a rough triangle with its apex toward the south (fig. 1). Thick interbedded limestone and shale of the Chase Group of Permian age underlie the more extensive, eastern part of the basin. Natural waters are dominantly of the calcium bicarbonate type. Shale and subordinate strata of limestone, gypsum, and dolomite of the Sumner Group underlie the western part of the basin. Natural waters are dominantly of the calcium sulfate type. Inflow from most east-bank tributaries dilutes streamflow of the Walnut River; west-bank tributaries, including the Whitewater River, contribute most of the sulfate.

Nearly all the ground water is hard to very hard. High concentrations of sulfate characterize waters from gypsiferous aquifers; high concentrations of chloride characterize ground waters affected by drainage from oil fields. Extensive fracture and dissolution of the Permian limestones facilitated pollution of ground water by oil-field brine and migration of the polluted water into adjacent areas. Ground water containing more than 1,000 mg/l (milligrams per liter) dissolved solids and more than 100 mg/l chloride is common near oil fields but is exceptional elsewhere. Sodium and chloride are the principle ionic constituents of oil-field brine but are minor constituents of natural surface waters or shallow ground water in the basin. The concentration of dissolved solids in the Walnut River generally decreased progressively downstream from the mouth of the Whitewater River to Winfield. During the 1964 water year, the concentration of dissolved solids at Winfield exceeded 1,000 mg/l about 50 percent of the time, and the concentration of chloride exceeded 250 mg/l about 60 percent of the time.

Pollution control markedly reduced the concentrations of chloride at corresponding rates of discharge after 1955 (fig. 2). However, concentrations of sodium and chloride were far higher, and sodium-chloride ratios were lower, than those that prevailed before extensive development of the oil fields. More than half of the annual load of chloride at Winfield during the 1964 water year consisted of residual salt from improper brine-disposal practices in the past. With continued effective pollution control, the concentrations of sodium, chloride, and dissolved solids should progressively decrease. The rate of decrease and the concentrations of the major ions in streamflow depend mainly on the amount, rate, and distribution of precipitation, on water and land use, and on control of streamflow by proposed impoundments.

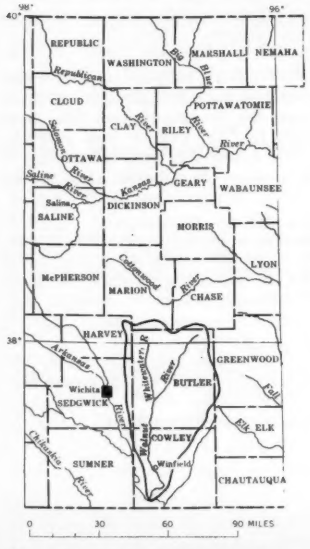


Figure 1.—Index map showing location of the Walnut River basin (shaded area), south-central Kansas.

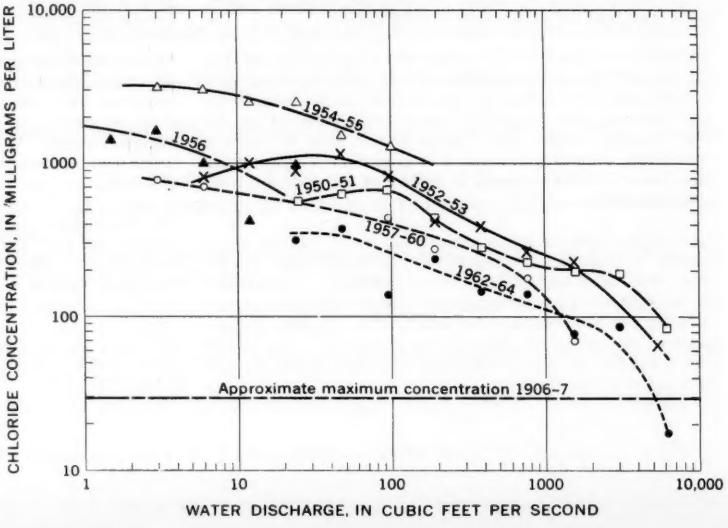


Figure 2.—Variation with time in the relation of the concentration of chloride ions to the daily mean discharge at Walnut River at Winfield during water years 1950–64.

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